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A TWO-IN-ONE TYPE UNDULATOR*

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Abstract

The high repetition-rate X-ray Free Electron Lasers based on superconducting radiofrequency technologies [1,2] have tremendous advantages in many aspects. Such a facility is able to serve many FEL photon beamlines simultaneously with each of which have large flexibilities in selecting wavelength, intensity, polarization, coherence and other properties through independent tuning of the undulator magnets. In reality a lot of spaces needed to accommodate many undulator lines could be a limiting factor of user capacity, especially for the high rep rate XFELs that tend to utilize the underground tunnel to host long superconducting accelerator machine with the relatively low acceleration gradient and for radiation safety considerations. In this paper we present a design of two-in-one type undulator for more efficiently using precious spaces in tunnels or similar buildings and open the possibilities for easier convene of different photon beams.

INTRODUCTION

The Shanghai Coherent Light Facility (SCLF) is a high repetition rate X-ray Free Electron Lasers based on superconducting radiofrequency technologies [3]. The superconducting electron accelerator and undulators as well as photon beamlines/endstations are all installed in underground tunnels with an overall length of more than 3 km. The electron beams are distributed in the switchyard shaft to different undulator lines. The current design assumes single tunnel for main accelerator and three tunnels for undulators and beamlines, all with an inner diameter of 5.9 m, as shown in Figure 1.

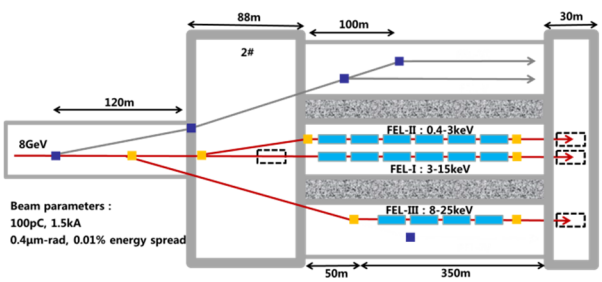

Figure 1: General layout of undulator lines of SCLF.

The dimension of cross section of tunnels is chosen to accommodate two conventional undulator lines and enough spaces for installations, illustrated in Figure 2.

The maximum number of FEL lines is mainly limited by the spaces of undulator tunnels. In the first phase of the project there are three undulator lines planned for producing bright FEL beams in hard and soft X-ray regimes. The FEL-I and FEL-II will be located at the central tunnel in parallel using conventional out-vacuum undulator technology. The FEL-III is going to adopt the superconducting undulator concept for achieving stronger magnetic field strength with small undulator period hence the higher photon energies with relatively moderate electron beam energy. Currently SCLF is designed to cover the wide range of photon energy from soft to hard x-ray with 8-GeV electron beam and three undulator lines. In future it is crucial for this kind of facility to maximize its ultimate capabilities of providing photon beamlines for scientific users.

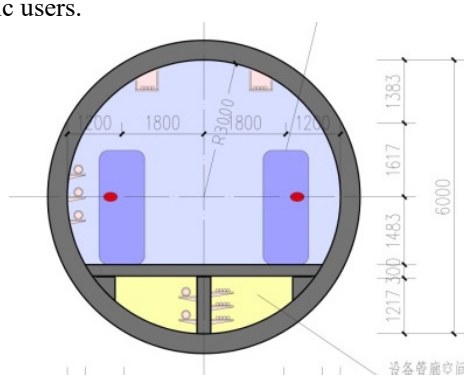

Figure 2: Cross section of undulator tunnel accommodating FEL-I and FEL-II lines.

TWO-IN-ONE UNDULATOR

A simple concept of two-in-one type of undulator was proposed in order to save the precious space in tunnels. Figures 3 and 4 illustrate the overall undulator layout.

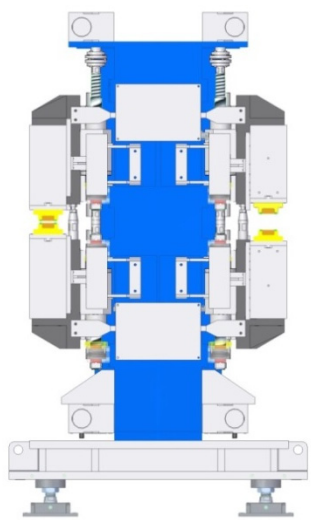

Figure 3: Concept of a two-in-one type of undulator.

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The proposed design has following features:

(a) The basic structure is mirror symmetric therefore the magnetic forces is better balanced than traditional undulators.

(b) Overall width (~1.3m) is almost same as the existing single-sided undulators.

(c) Distance between beam centers is about 0.96 m, enough for two lines of components in parallel.

(d) Enough space between undulators for transport and installation work near the tunnel walls. The space of 1.5 m width between undulator lines is available for transporting undulators and 0.9 m between tunnel wall and outer undulator magnet for component installations.

(e) The short distance between two photon beams makes it easier to bring them to the same endstation for pump-probe or other kinds of experiments with completely independent controlled X-ray pulses. There are large flexibilities in choosing wavelength, polarization, coherence, intensity and pulse duration, etc.

(f) With this type of undulator design each tunnel with 5.9m-diameter may accommodate up to four independent undulator lines, as can be observed in Figure 5.

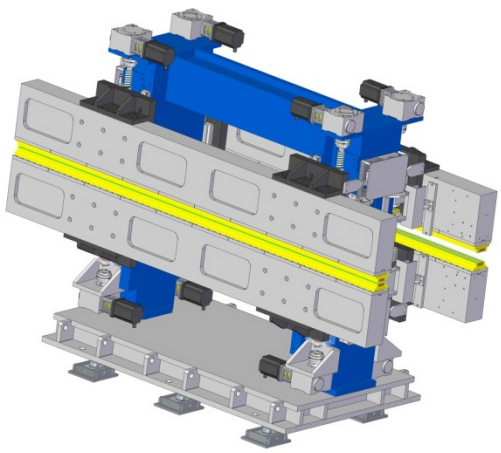

Figure 4: Overall view of the proposed 3-meter prototype undulator.

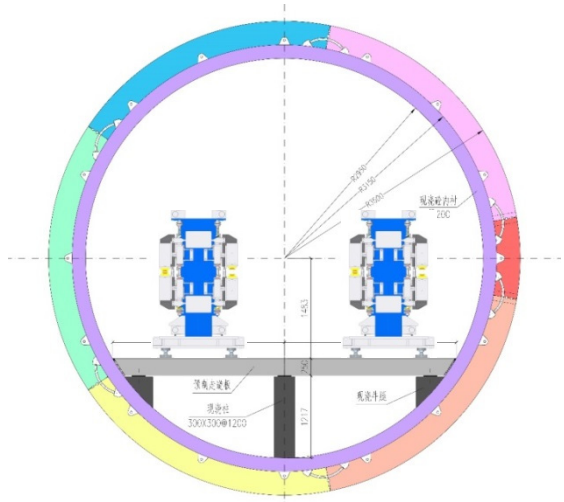

Figure 5: Cross section of the undulator tunnel with two undulators.

The new layout with two-in-one type undulator in the SCLF tunnels shows that it is feasible to install two such undulator lines therefore four FEL lines with independent tuning capabilities of the photon properties.

On the other hand, one usually needs to diverse photon beams from two-in-one undulates to the different endstations. Also it is obvious that two undulator lines must have the identical length for each unit including undulator magnet and components between the adjacent undulators.

In order to verify the robustness and study mechanical performance of this type of concept, an engineering design of a full-size prototype undulator has been completed [4]. Figure 6 shows the final engineering layout. The order is placed to a company for manufacturing a 3-meter-long full size prototype undulator frame for further studies.

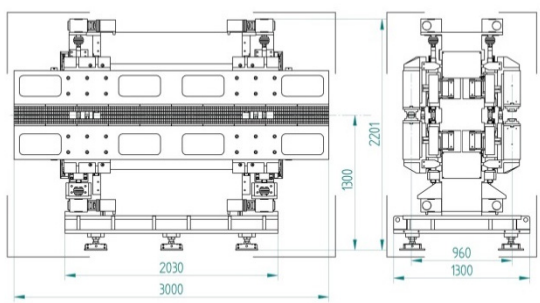

Figure 6: Engineering design of the type of undulator in the SINAP.

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CONCLUSION

A concept of two-in-one undulator magnet is proposed to utilize the space in tunnel more efficiently. The concept has several advantages on achieving independently tuning flexibilities of two different XFEL photon beams within comparable spaces to the conventional out-vacuum undulators, which may pave the way of maximizing the capabilities of photon beamlines of future high rep rate X-ray Free Electron Lasers.

ACKNOWLEDGEMENT

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